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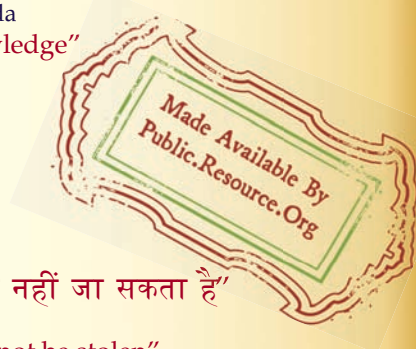
IS 9745 (1981): Method for determining strength giving properties of asbestos fibre [CED 53: Cement Matrix Products]



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( Reaffirmed 2001 )

# *Indian Standard*

## METHOD FOR DETERMINING STRENGTH GIVING PROPERTIES OF ASBESTOS FIBRE

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# Indian Standard

## METHOD FOR DETERMINING STRENGTH GIVING PROPERTIES OF ASBESTOS FIBRE

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## *Indian Standard*

# METHOD FOR DETERMINING STRENGTH GIVING PROPERTIES OF ASBESTOS FIBRE

### 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 30 January 1981, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

**0.2** A series of standards on testing procedures for asbestos fibre are being formulated so as to provide standard methods for obtaining physical and chemical properties of asbestos fibre which is used for manufacturing asbestos cement products like asbestos cement sheets, pipes, etc. These testing procedures will be useful both for mine owners and the manufacturers of asbestos cement products provided they have the facilities to perform these tests with reasonable accuracy and personnel with the required degree of laboratory experience. These standards which will define the properties of asbestos fibre suitable for manufacturing asbestos cement products will also be useful for utilizing indigenous asbestos for various asbestos cement products.

**0.3** This standard covers the method of test for evaluating the strength giving properties of asbestos fibres used to reinforce asbestos cement products. This method of test facilitates the comparison of different types and grades of asbestos fibre by the property most pertinent to its use in asbestos cement, namely the strength it imparts to the product. This method covers the fabrication and flexural testing of asbestos cement test specimens, which contain asbestos fibre from the sample being evaluated.

**0.3.1** In this method of test, the strength giving properties of asbestos fibre are determined in terms of strength units (S. U. ) it possesses. Thus, fibre with good S. U. values will be required for the production of high strength asbestos cement products. Every fibre grade possesses a certain number of strength units. The quantity of fibre required in an asbestos cement composition varies inversely with the number of strength units it possesses. For example, if  $x$  amount of a fibre possessing 100 S. U. produces a product of a given strength,  $2x$  would be required to produce a product of equivalent strength from a fibre possessing only 50 S. U.

**0.3.2** An asbestos fibre that gives the standard strength at the standard density when used as 10 percent of the furnish is defined as having 100 S. U. Therefore, by knowing the 10 percent fibre required in the mix to give standard strength at the standard density it is possible to calculate the strength units of a sample of asbestos fibre. This is the basis for the strength unit test.

**0.4** In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by basing the standard on 'Chrysotile Asbestos Test Manual' 1974 (*Revised* 1978 ). Asbestos Textile Institute, Inc. and Quebec Asbestos Mining Association.

**0.5** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960\*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

## 1. SCOPE

**1.1** This standard covers the procedure for evaluating the strength giving properties of asbestos fibres used in asbestos cement products.

## 2. APPARATUS

### 2.1 Ball Milling

**2.1.1 Porcelain Ball Mill Jars with Neckbands, Gasket and Covers** — Conforming to the following requirements:

|                   |                        |
|-------------------|------------------------|
| Capacity          | 11,000 cm <sup>3</sup> |
| External diameter | 280 mm                 |
| Internal diameter | 230 mm                 |
| Internal height   | 210 mm                 |

**2.1.2 Porcelain Balls, Machine-made or Hand-made** — Conforming to the following requirements:

|                  |                                               |
|------------------|-----------------------------------------------|
| Diameter         | 40 mm                                         |
| Mass ( each )    | $74 \times 10^{-3}$ to $75 \times 10^{-3}$ kg |
| Specific gravity | $2.3 \pm 0.1$                                 |

**NOTE** — When the diameter of the balls is 35 mm or less, the balls shall be discarded.

\*Rules for rounding off numerical values (*revised* ).

**2.1.3 Roll Table** — to rotate the ball mill jars at  $6.81 \pm 0.21$  rad/s ( $65 \pm 2$  rpm).

## 2.2 Fiberizing

**2.2.1 Disintegrator** — driven at  $565 \pm 21$  rad/s ( $5\,400 \pm 200$  rpm) by a squirrel cage induction motor rated at no less than 1.492 kW.

**2.2.2 Perforated Steel Discharge Plates for Fiberizer** — One each of 3, 5, 7, and 10 mm opening diameters respectively.

**2.2.3 Cardboard Drum** — Of approximately 410 mm diameter and 400 mm high with removable ring clamp on top, and canvas dust cover with other necessary arrangements for receiving the fiberizer discharge which are satisfactory with respect to relief of static pressure generated by the fiberizer rotor, and with respect to the prevention of sample losses and contamination.

## 2.3 Blending

**2.3.1 Polyethylene Jar with Cover** — Conforming to the following requirements:

|                  |        |
|------------------|--------|
| Inside diameter  | 311 mm |
| Outside diameter | 327 mm |
| Inside height    | 311 mm |

Other containers such as stainless steel blenders with similar internal dimensions may be used.

**2.3.1.1** The jar may be fitted with a circumferential rubber tension band to retain the cover, alternatively the cover may be retained by mechanical clamps.

**2.3.1.2** The jar may be fitted with tires around the outer diameter to allow it to roll on a roll-table in a horizontal attitude.

**2.3.2 Roll Table** — to rotate the blending jar at a speed of  $5.87 \pm 0.21$  rad/s ( $56 \pm 2$  rpm).

**2.3.3 Rolling Sheet** — one meter square or larger, made of rubber, plastic, or some other flexible elastomer.

## 2.4 Dry-Mixing

**2.4.1 Polyethylene Jar with Cover** — Conforming to the following requirements:

|                  |                        |
|------------------|------------------------|
| Inside diameter  | 248 mm                 |
| Outside diameter | 257 mm                 |
| Inside height    | 273 mm                 |
| Capacity         | 13 200 cm <sup>3</sup> |

Other containers, such as stainless steel mixers, with similar internal dimensions may be used.

**2.4.1.1** The jar may be fitted with a rubber band to retain the cover.

**2.4.1.2** The jar may be fitted with tires as described in 2.3.1.2.

**2.4.1.3** The interior of the jar may be fitted with three mixing vanes located  $2.09 \text{ rad}$  ( $120^\circ$ ) apart, along the full length of the jar and projecting  $38.0 \text{ mm}$  from the inside wall. The vanes may be fastened to the wall by smooth head rivets, or an adhesive. The corners of the vanes at the jar opening should be rounded to a radius of  $13 \text{ mm}$ , the vanes may be fabricated from aluminium or any other corrosion-resistant sheet metal  $1.0 \text{ mm}$  thick.

**2.4.2 Roll Table** — to rotate the blending jar at a speed of  $8.17 \pm 0.21 \text{ rad/s}$  ( $78 \pm 2 \text{ rpm}$ ).

NOTE — If a judicious choice of drive roll diameter and speed is made for the roll table, together with suitable tire dimensions for containers mentioned in 2.1.1, 2.3.1, and 2.4.1, it is possible to use the same roll table for three containers; for example, if the drive roll has a diameter of  $125 \text{ mm}$  and a speed of  $17.3 \text{ rad/s}$  ( $165 \text{ rpm}$ ), the appropriate speed would be obtained for each container if tires are adjusted to bring the effective outer diameter to  $311 \text{ mm}$  for the ball mill jars,  $361 \text{ mm}$  for the blending jars and  $259 \text{ mm}$  for the dry mixing jars.

## 2.5 Wet Mixing

**2.5.1 Wet Mixer** — as described in Fig. 1. The drive motor shall be able to maintain a speed of  $62.83 \pm 2.62 \text{ rad/s}$  ( $600 \pm 25 \text{ rpm}$ ) under load.

**2.5.2 Impeller** — The impeller shall rotate clockwise when looking from above, and the vanes shall be so pitched as to impel the slurry downward. A plastic casting may be substituted for the rubber stoppers which are called for in the design of the impeller. The maximum clearance between the impeller and the conical wall of the wet mixer shall be set at  $6.3 \text{ mm}$ .

**2.5.3 Rubber Hoe** — as shown in Fig. 2.

## 2.6 Pressing

**2.6.1 Semi-automatic Press** — ( see Fig. 3 ) — capable of performing the pressing cycle as described in 2.6.1.1 and 2.6.1.2.

**2.6.1.1 Manual control** — Start with the toggle switch in the OFF position. If contact is maintained on the UP push button, or on the UP foot switch, the press will close and as it closes, the pressure will rise until it reaches a value pre-selected on the high pressure relief valve. The press may be opened by pushing the down button which will open solenoid valve No. 2 and drop the ram, or by opening the manual dump valve.

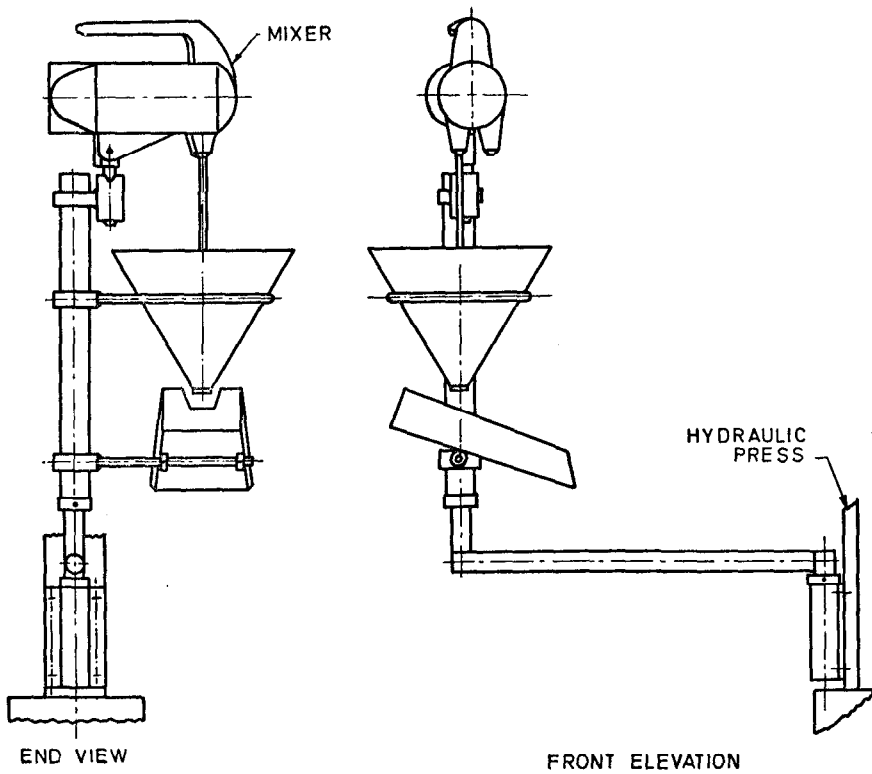


FIG. 1 WET MIXER ASSEMBLY

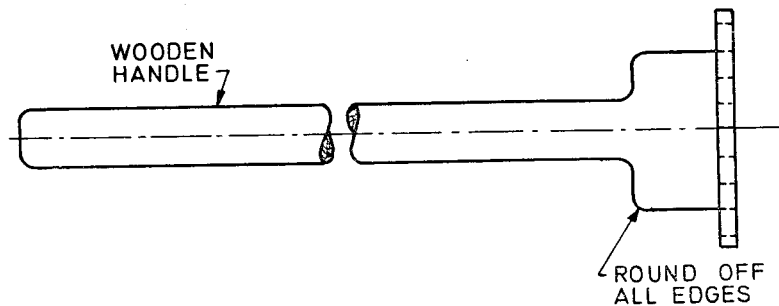
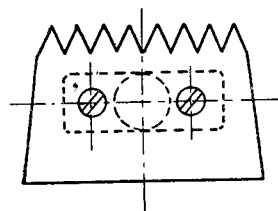
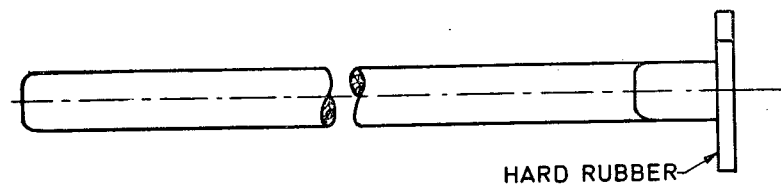
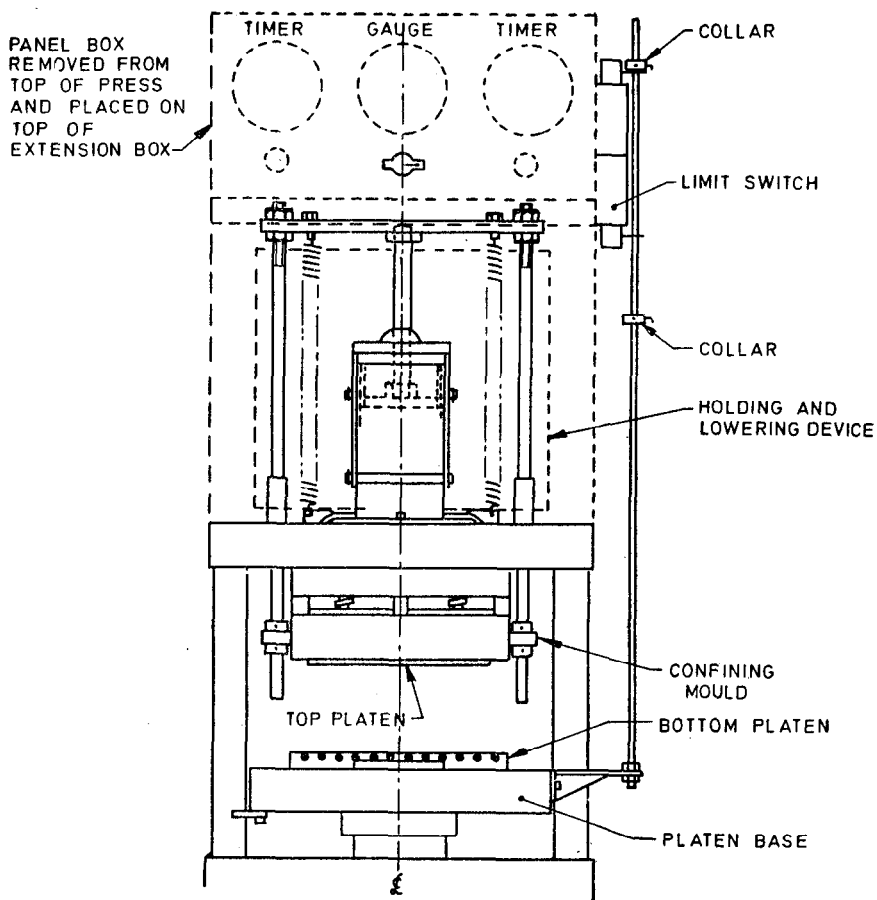


FIG. 2 RUBBER HOE



FRONT ELEVATION

FIG. 3 GENERAL PRESS ASSEMBLY (Contd)

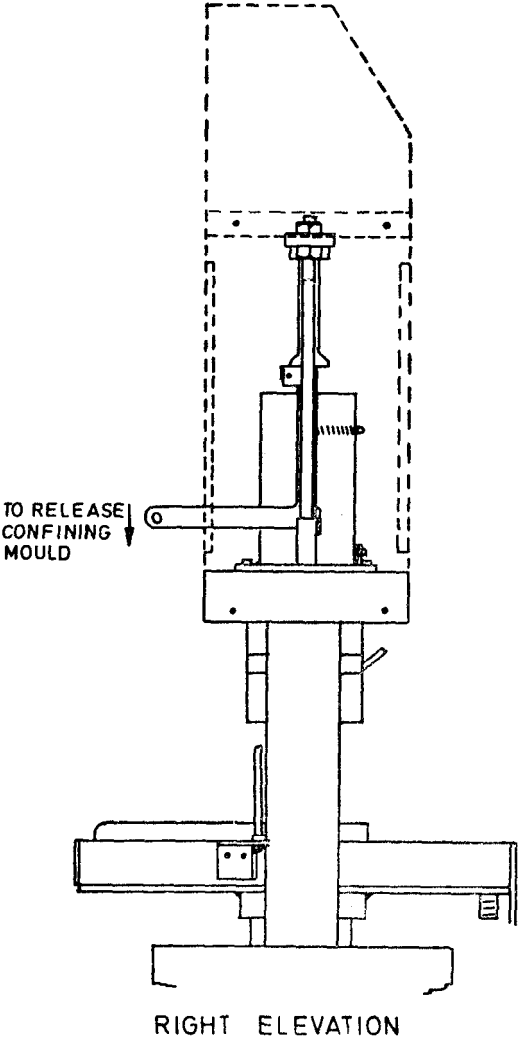


FIG. 3 GENERAL PRESS ASSEMBLY

**2.6.1.2 Automatic control** — Set timer No. 1 to the required low pressure interval of 105 s, and timer No. 2 for the high pressure interval of 90 s. Put the toggle switch in the ON position. The cycle may be started by closing either the foot switch or the push button, and the following events will occur:

- a) The top limit switch will close at any required point in the ram travel, the pump will continue to run and solenoid valve No. 1 will open.
- b) When the press closes, pressure will rise to the value set on the low pressure relief valve.
- c) After the pre-selected interval ( 105 s ), timer No. 1 times out.
- d) Automatically timer No. 2 starts. Solenoid valve No. 1 closes and pressure will rise at an adjustable rate to the value set on the high pressure relief valve.
- e) At the end of the interval selected on timer No. 2 ( 90 s ), the motor stops and solenoid valve No. 2 opens permitting the ram to drop.
- f) As the ram bottoms, the lower limit switch opens, causing the timer to re-set preparatory to another cycle.

The rate of pressure rise to the high pressure relief valve setting may be controlled by adjusting the micrometer valve. This system will operate for some time without over-heating but when continuous operation is planned, water should be circulated through the heat exchanger.

**2.6.2 Device for Holding and Lowering Confining Mould** — ( see Fig. 3 )

**2.6.3 Top Platen** ( see Fig. 3 )

**2.6.4 Confining Mould** ( see Fig. 3 )

**2.6.5 Bottom Platen** ( see Fig. 3 )

**2.6.6 Platen Base** ( see Fig. 3 )

**2.6.7 IS Sieve 425 Micron** — measuring 240 mm in length and 130 mm wide.

**2.6.8 IS Sieve 1.18 mm** — measuring 240 mm in length and 130 mm wide.

**2.6.9 Perforated Steel Plate** — Measuring 240 mm in length and 130 mm wide and conforming to the following requirements:

Thickness : 1.24 to 1.68 mm.

Diameter of perforations : 3.18 mm  $\pm$  5 percent

Width of the metal between holes : 2.38 mm  $\pm$  20 percent

Pitch of the holes : Triangular ( equilateral )

**2.6.10 *Settling-Tank*** — 130 mm wide, 640 mm long, and 500 mm deep, made of galvanized sheet steel with an overflow drainage system.

**2.6.11 *Asbestos Cement or Plastic Plates*** — measuring  $90 \times 220 \times 6$  mm.

## 2.7 Curing

**2.7.1 *Humidity Cabinet*** — capable of providing relative humidity between 90 and 100 percent at room temperature.

**2.7.2 *Autoclave*** — 460 mm internal dia and 760 mm long capable of maintaining  $0.7 \text{ N/mm}^2$  gauge pressure of saturated steam ( not superheated ) at  $170^\circ\text{C}$  for a period of 20 h.

**2.7.2.1 *Autoclave trays*** — of steel plate  $610 \times 355 \times 6$  mm with a handle at one end.

**2.7.2.2 *Autoclave basket*** — ( see Fig. 4 )

**2.7.2.3 *Asbestos cement cover sheet*** — measuring  $360 \times 610 \times 6$  mm.

**2.7.3 *Saturating Tank*** — large enough to saturate one day's production of test specimens each measuring approximately  $75 \times 200 \times 6$  mm.

## 2.8 Testing and Measuring

**2.8.1 *Flexural Testing Machine*** — capable of applying a load of 490 N at the rate of  $5.88 \pm 0.29 \text{ N/s}$ . For testing machines with a constant rate of loading, these shall be capable of extending at the rate of  $0.1 \text{ mm/s}$ . The dynamometer shall read to 1 N and may be equipped with a trailing needle or other mechanism to record maximum load attained on each test.

**2.8.1.1** The specimen grips on the flexural tester may be of the centre point loading type with a span of 152 mm and the bearing edges of the loading bars may have a radius of 6.35 mm and shall be free to rotate in a plane perpendicular to the test specimen, and load direction.

**2.8.2 *Micrometer*** — 0 to 25 mm range, reading to 0.01 mm with spindle and anvil flat.

**2.8.3 *Drying Oven*** — capable of maintaining a temperature of  $105^\circ\text{--}110^\circ\text{C}$  and of sufficient size to hold one day's production of test specimens.

## 3. MATERIALS

**3.1 *Cement*** — Ordinary Portland cement conforming to IS : 269-1976\*.

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\*Specification for ordinary and low heat Portland cement ( *third revision* ).

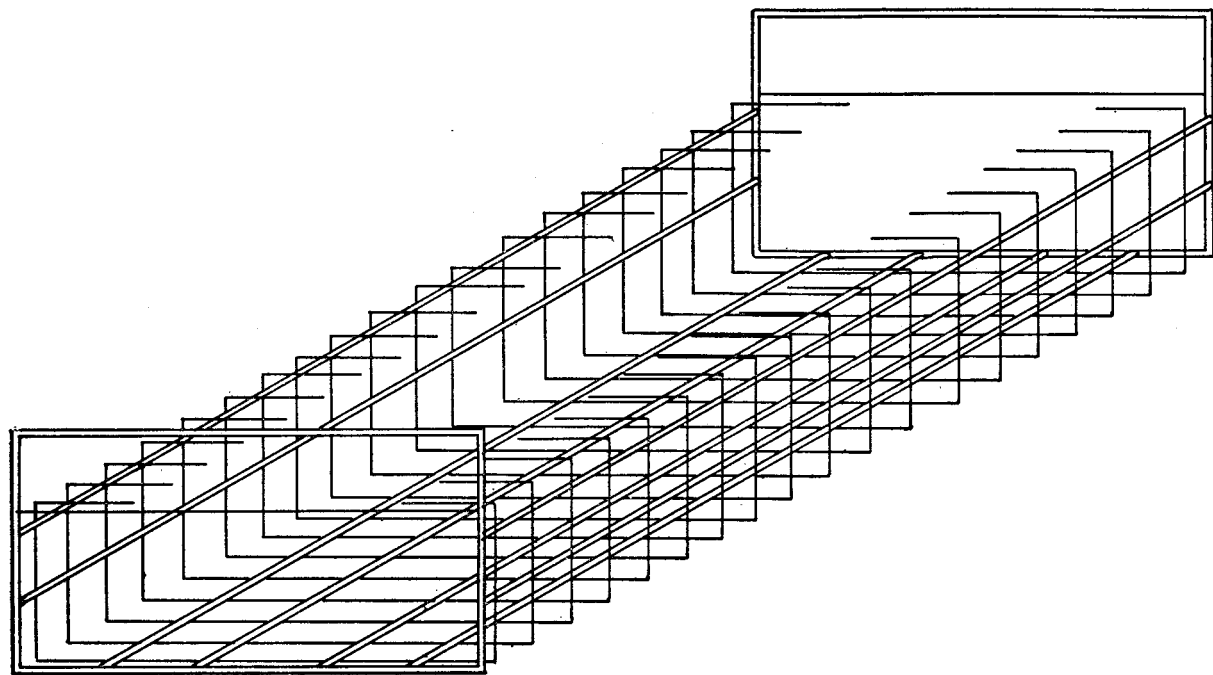


FIG. 4 SPECIMEN BASKET

**3.2 Silica ( Ground Quartz )** — Conforming to the following requirements:

- a)  $\text{SiO}_2$  content 99 percent minimum  
 b) Size distribution by wet sieve analysis :

| <i>IS Sieve</i> | <i>Percentage Passing</i> |
|-----------------|---------------------------|
| 180 Micron      | 99                        |
| 150    ,,       | 90                        |
| 75     ,,       | 85                        |

- c) Blaine specific surface area  $3\,300 \pm 300 \text{ cm}^2/\text{g}$

NOTE — For better reproducibility of results, it is advisable to procure ordinary Portland cement and ground silica from a common source of supply for fibre evaluation. It is essential that the properties of these materials remain constant in order to avoid differential effect of these materials on the ultimate strength of the asbestos cement samples, independent of the effect of fibre on strength.

**3.3 Saturated Water** — The water used in the preparation of the samples shall be distilled water saturated with calcium hydroxide  $[\text{Ca}(\text{OH})_2]$  and calcium sulphate (Gypsum)  $(\text{CaSO}_4, 2\text{H}_2\text{O})$  of sufficiently high purity. This water is prepared by adding 2 grams of calcium hydroxide and 3 grams of gypsum per litre. It shall be allowed to stand for 24 h ( agitating water from time to time ) after which it is siphoned off into clean containers. If the temperature of the saturated water fluctuates, precipitation of the dissolved salts may occur. For this reason, it is preferable to filter this water at the point of use for wet mixing purposes.

**4. SAMPLING**

**4.1** The sample shall be laboratory test sample, sampled in accordance with IS : 4844-1968\*.

**4.2** The quantity of fibre required may range from 0.3 to 0.6 kg for higher and lower strength imparting samples, respectively, assuming that retesting will not be necessary.

**4.2.1** A 0.3 kg asbestos sample charged to the ball mill may be expected to yield approximately 0.25 kg after various losses due to the fibre preparation steps.

**4.2.2** The quantity of prepared fibre required to give standard strength shall be predicted in advance. Predictions may be based upon previous fibre strength unit results obtained on the same grade or on a similar grade of asbestos.

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\*Method of sampling and preparation of asbestos fibre for laboratory test purposes.

**4.2.3** If no basis is available for predicting the strength unit value of the sample under test; it may be assumed that this value is 100 as a first approximation, and the asbestos requirement may be calculated on the basis that mass of prepared fibre required is equal to 17 ( strength units ) in kg.

**4.2.4** If prepared fibre requirements exceed 0.25 kg, an additional 0.3 kg aliquot may be selected from the sample, this additional aliquot

## 5. PROCEDURE

### 5.1 Ball-Milling

**5.1.1** Place  $6 \pm 0.04$  kg of porcelain balls in a ball mill jar, add 0.3 kg of asbestos on top of the balls, close the jar securely, and place it on the roll table.

**5.1.2** Roll the jars at  $6.81 \pm 0.21$  rad/s (  $65 \pm 2$  rpm ) for that time which ultimately gives the highest strength to the asbestos cement specimens.

NOTE — It is significant to recognize that the degree of conditioning required by the ball milling phase of this particular preparatory treatment procedure is dependent on specific fibre characteristics produced from individual ore bodies and indeed from different mining areas. The optimum ball milling time required for chrysotile fibre is generally found to be within the range 45-90 min.

**5.1.3** Discharge the contents of the ball mills into a clean container and brush or wipe clean of fibre each ball, as well as the interior of the jars.

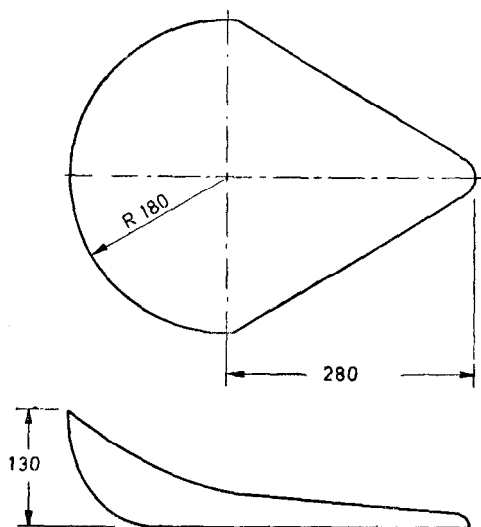
### 5.2 Fiberizing

**5.2.1** Select the appropriate disintegrator discharge plate from the table given below and mount this plate onto the disintegrator, close the access port, fasten it securely, and start the motor:

| <i>Grade<br/>Designation of Chrysotile<br/>Asbestos Fibre ( Quebec<br/>Standard )</i> | <i>Diameter of Holes in<br/>Perforated Plates,<br/>mm</i> |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 3                                                                                     | 10                                                        |
| 4                                                                                     | 7                                                         |
| 5                                                                                     | 5                                                         |
| 6                                                                                     | 3                                                         |

NOTE — A 10 mm plate size is optional for 4-Group fibres of types that benefit by ultimately giving higher strength results.

**5.2.2** Feed the ball-milled asbestos fibre directly into the inlet chute of the disintegrator, by passing the feed hopper which has a tendency to clog by means of feeding pan ( *see* Fig. 5 ) at a uniform rate of 0.3 kg per 90-120 s in a uniform flow so as to maintain a constant disintegrator speed. Changes in speed may be detected from changes in the pitch of the sound emitted by the machine.



All dimensions in millimetres.

FIG. 5 FIBERIZER FEEDING PAN

**5.2.3** Stop the motor and dislodge any agglomerations of asbestos which may have accumulated on the stator lugs and in interior cavities, add these clots to the sample.

**5.2.4** Pass the sample through the disintegrator second time and discard any asbestos which remains hung up inside the disintegrator.

### 5.3 Blending

**5.3.1** Place the fiberized sample in a blending jar and roll at  $5.87 \pm 0.21$  rad/s (  $56 \pm 2$  ) rpm on a roll table for 10 min.

**5.3.2** If two separate ball mill charges of 0.3 kg each are required, then split the disintegrated sample approximately in half, and blend each half in a separate blending jar. In this case, mix the contents of both jars after blending by means of the rolling sheet in such a way as to prevent segregation and to minimize stratification.

## 5.4 Dry Mixing

**5.4.1** Based upon the fibre mass determined in 4.2.3, calculate the mass in kg of Portland cement and silica required as  $0.625 [ 1.7 - (\text{fibre mass in kg}) ]$  and  $0.375 [ 1.7 - (\text{fibre mass in kg}) ]$  respectively.

**5.4.2** Add the masses of prepared asbestos fibre, Portland cement and silica to the dry mixing jar, secure the cover and roll on the roll table at  $8.17 \pm 0.21 \text{ rad/s}$  ( $78 \pm 2 \text{ rpm}$ ) for 5 min.

**5.4.3** Discharge the dry mixing jar onto the rolling sheet and roll the dry mix by lifting opposite ends of the sheet alternately, using two rolls per end for a total of four rolls.

**5.4.4** Repeat this rolling operation before taking each portion of dry mix during the pressing of the individual specimens made from the mix and alternate the direction of rolling after taking each specimen.

**NOTE** — It is preferable to process the test specimens as quickly as possible after dry mixing to limit the deleterious effects of prehydration of the Portland cement by contact with moisture in the asbestos or in the atmosphere. Dry mixed samples containing cement may not be exposed to the atmosphere for more than two hours. Dry mixed samples may be kept in storage in plastic or moisture-proof containers for periods not exceeding one week.

**5.4.5** Do not compress the dry mix in any way.

## 5.5 Preliminary Steps for Producing Test Specimens

**5.5.1** Clean the press screens and the perforated plate before each pressing cycle, using running water and a stiff bristle brush.

**5.5.2** Clean the retaining mould and the top platen die with a cloth.

**5.5.3** Oil the bottom surface of the top platen die by means of a brush dipped into a mixture of ten parts kerosene to one part raw linseed oil.

**5.5.4** Place the lower platen in position on the platen base and pull it forward as far as it will go.

**5.5.5** Stack the following items on top of the lower platen in the order given below:

- a) Perforated plate,
- b) IS Sieve 1.18 mm,
- c) IS Sieve 425 micron, and
- d) Retaining mould.

**5.5.6** *Press Adjustments and Settings*

**5.5.6.1** Control the pressure attained during the dewatering phase on the press by turning the low pressure relief valve handle counter clockwise to obtain minimum pressure. This pressure may not exceed  $6.9 \text{ MN/m}^2$  as shown on press gauge.

**5.5.6.2** Control the rate of rise by adjusting the full flow valve in the hydraulic circuit of the press. Set the full flow valve to compress top platen springs fully as close as possible to 30 s before the end of the low pressure cycle. This helps to minimize loss of material without affecting the high pressure cycle rate of rise. Measure the rate of rise by means of a 6 mm thick metal to replace the slurry.

**5.5.6.3** Adjust the limit switch, which starts the low pressure timer so that, it starts timing when the top of the confining mould is in the same horizontal plane as the bottom of the upper platen ( *see* Fig. 3 ).

**5.5.6.4** The upper platen die ( *see* Fig. 3 ) is fitted with suction nozzles that serve to aspirate water that is forced out between the mould and the die when it comes into contact with the slurry. These nozzles shall be connected, through a liquid trap by means of hoses, to a source of vacuum. A vacuum of 75 mm Hg has been found satisfactory, when set with pinched suction lines ( 8 mm bore ) by means of a diaphragm type regulator located 1.2 mm from the suction nozzle outlets. Connect the suction nozzles on the mould to a suction flask by means of two separate parallel hoses which are led through the rubber stopper of the suction flask by means of metal tubes. A  $4 \text{ dm}^3$  suction flask is recommended. Installation of the vacuum regulator as close as convenient to the suction flask outlet nozzle has been found satisfactory. Tap the vacuum manometer directly into the rubber stopper of the suction flask.

**5.5.6.5** The lower platen base is fitted with a drainage nozzle to dispose of the water which is forced out through the screens when the die contacts the slurry in the mould. Connect this nozzle with a hose to the settling tank.

**5.5.6.6** Set the rate of rise control valve, so that 234.4 MPa gauge pressure will be attained after 30 s in the high pressure cycle.

**5.5.6.7** Adjust the high pressure relief valve to maintain 234.4 MPa gauge pressure throughout the last 60 s of the cake formation phase.

**5.5.6.8** Adjust the extension of the upper platen springs by means of the socket head shoulder screws which retain them. Set the extension so that the top die will extrude the specimen cake from the confining mould at the end of pressing cycle such that the bottom of the die will project below the bottom surface of the confining mould by a distance of  $0.203 \pm 0.050 \text{ mm}$ .

**5.5.6.9** Adjust the spacers so that cake thickness will be  $6 \pm 0.25$  mm. Thickness may be decreased by surface grinding the spacers. Increased thickness may be obtained by the use of steel shims of appropriate thickness.

**5.5.6.10** Check the brass loading bars for wear and replace these if wear exceeds 0.127 mm.

## 5.6 Wet Mixing

**5.6.1** Rinse the wet mixing cone and insert a rubber stopper at the bottom.

**5.6.2** Pour 0.4 litre of saturated water at 27°C into the cone.

**5.6.3** For the first test specimens, start the wet mixer motor and immediately add 0.145 kg of dry mix. For subsequent test specimens, wait until the start of the high pressure cycle on the specimen press, and then immediately start the wet mixer motor and add 0.145 kg of the dry mix. Mixing shall be done for two minutes.

NOTE — The timing for the sequence of test specimen formation is continuous from this point, the time at which the mixer is started being zero.

**5.6.4** Add an additional 0.05 litre of saturated water to rinse down the walls of the cone, while the mixer motor is running.

**5.6.5** As the end of the two minute wet mixing period approaches, swing the wet mixer on its swivel support so that the discharge chute leads directly to the specimen mould on the press.

**5.6.6** *Transfer of Slurry* — Transfer of slurry shall be done during 120 to 165 s.

**5.6.6.1** When the time reaches 120 s, stop the mixer motor and simultaneously remove the stopper at the bottom of the cone to discharge the slurry into the mould by means of the chute.

**5.6.6.2** After the slurry has been discharged, spin the mixer motor briefly to clean the impeller by centrifugal force.

**5.6.6.3** Clean the walls of the cone by means of a rubber spatula.

**5.6.6.4** Clean the chute by means of the straight edge on the rubber hoe.

**5.6.6.5** Distribute the slurry evenly in the mould by the toothed edge of the rubber hoe. Carry out this operation carefully in a few strokes to prevent segregation. The entire slurry transfer should be in 45 s.

## 5.7 Pressing

**5.7.1** After the preliminary steps ( *see 5.5* ) and transfer of the slurry, push back the confining mould and bottom platen assembly together until they are directly beneath the top platen die and the confining mould hooks contact the yoke rods between the set screw collars.

### 5.7.2 Dewatering Time

**5.7.2.1** Dewatering time shall be from 165 s to 270 s. Start the cycle by opening the safety switch and closing the foot switch. The low pressure timer is thus activated.

### 5.7.3 Cake Formation

**5.7.3.1** Cake formation time shall be from 270 s to 360 s. After the dewatering interval, timer No. 1 automatically shuts off and starts timer No. 2 which controls the cake formation period.

**5.7.3.2** The pressure will rise to 234.4 MPa gauge pressure in 30 s and remain at that level for a dwell time of 60 s.

### 5.7.4 Specimen Cake Discharge

**5.7.4.1** At the end of dwell time interval ( 360 s of the continuous timing sequence ), timer No. 2 times out and the press pump motor stops.

**5.7.4.2** The ram will drop and the top die will be forced away from the supporting plate of the top platen by the springs. Since the confining mould is supported rigidly by the holding device, the top die will pass through the confining mould, thus exposing the specimen cake for removal.

**5.7.4.3** As the ram drops, insert a flat asbestos cement or rigid plastic sheet between the specimen on the top of the screen on the bottom platen to receive the specimen. Maximum clearance between the bottom of the cake and top of the receiving sheet should be 6 mm, in order to protect the specimen from excessive flexing.

**5.7.4.4** If the specimen does not fall of its own accord, strip it carefully from the die by inserting a thin spatula between the cake and the die.

**5.7.4.5** Remove the receiving sheet with the specimen cake on top from the press and smooth any rough edges or flashing with the spatula. Ensure that the bottom of the spacer does not carry water to the top of the preceding cake. Identify the specimen by suitable means.

**5.7.4.6** Clean the screens and the perforated plates by brush in running water and return to the grooved lower platen for the next test.

**5.7.4.7** Lower the confining mould by releasing the moulding device. Wipe remnants of the slurry from the mould and die with emphasis on the sides of the die in order to prevent clogging of the suction system channels. The latter shall be kept clean to obtain reproducible results.

## **5.8 Specimen Curing**

### **5.8.1 Moist Cure**

**5.8.1.1** Stack the receiving sheets bearing the pressed cakes one above the other, and keep the pile covered with a wet cloth during the pressing of the other specimens from the same batch.

**5.8.1.2** When the entire batch is pressed, transfer the pile of specimens and receiving sheets along with wet cloth to the humidity cabinet at 90 to 100 percent relative humidity at room temperature for a minimum period of 16 h and a maximum period of 72 h.

### **5.8.2 Autoclaving**

**5.8.2.1** After the moist curing period is completed, remove the specimens from the humidity cabinet, and separate the specimens from the receiving sheets. If the specimen adheres to the receiving sheet, tap the latter on edge to dislodge it.

NOTE — Wax the receiving sheets to prevent adherence.

**5.8.2.2** Stack the specimens in a wire basket ( *see* Fig. 4 ) and place the basket on the autoclave tray. Alternatively, stack manually.

**5.8.2.3** Close the autoclave and raise the pressure to  $0.7\text{N/mm}^2$  within two hours.

**5.8.2.4** Bleed off steam from the autoclave to remove all the air which was enclosed initially. When all the air has been purged, cure the specimens at a saturated steam temperature of  $170 \pm 5^\circ\text{C}$  for 20 h.

NOTE — Since thermometers are inherently more reliable than the common pressure gauge, operate the autoclave on temperature basis. Make sure that the steam supplied is only saturated steam.

### **5.8.3 Saturation**

**5.8.3.1** After autoclaving, remove the specimens immediately from the autoclave and allow them to cool in air at room temperature sufficiently to prevent warming the immersion water beyond the limits allowed.

**5.8.3.2** Immerse the specimens in clean water at  $27^\circ \pm 2^\circ\text{C}$ , so that the specimens are completely covered for 24 h. Leave the cakes in the baskets during immersion. Alternatively stack the cakes manually.

## 5.9 Specimen Measurement and Testing

### 5.9.1 Immersed Specimen Mass

**5.9.1.1** Weigh each specimen while completely immersed in clean water at  $27^{\circ} \pm 2^{\circ}\text{C}$ .

**5.9.1.2** Record immersed mass for each specimen to the nearest 0.000 1 kg and return each specimen to saturating tank, while the other specimens are being weighed.

### 5.9.2 Saturated Specimen Mass

**5.9.2.1** Remove the basket from the saturating tank and support it at a compound angle of  $45^{\circ}$  from the vertical. Alternatively, stack manually.

**5.9.2.2** Allow the specimens to drip dry for a period extending from 7 to 15 min, and determine the saturated mass. Start weighing specimens after 7 min and continue weighing until all the specimens are weighed, or until the time limit of 15 min has been reached, whichever occurs first. If the specimens cannot be weighed in the allowed time, return the unweighed specimens to the saturating tank for an additional period of 15 min before repeating the procedure for drying and weighing.

**5.9.2.3** Record the saturated masses for each specimen to the nearest 0.1 g and re-immerses the specimens or cover them with a wet cloth until flexural testing is begun.

### 5.9.3 Flexural Testing

**5.9.3.1** Load each specimen in flexure until fracture of the specimen occurs. Load at the constant rate of  $5.89 \pm 0.29$  N/s. Alternatively, a flexural tester with a constant rate of extension may be used. In the latter case, set the rate of extension at 0.1 mm/s.

**5.9.3.2** Record the maximum load, called the breaking load to the nearest 1N for each specimen.

NOTE — Flexural tester dynamometer equipped with a trailing needle to record the maximum load attained is preferable. Otherwise, make every effort to observe the maximum load attained before incipient failure deformation of specimen occurs.

### 5.9.4 Specimen Thickness

**5.9.4.1** Measure the thickness near the fracture on one of the broken halves. Place the centre of micrometer anvils at approximately 13 mm from the fracture at mid-width, and measure thickness to the nearest 0.01 mm. Then locate the centre of the micrometer anvils at approximately 13 mm from the fracture, at approximately 13 mm from each side of the specimen and measure thickness at both locations.

**5.9.4.2** Take care that the micrometer anvils are not too near the cake sides ( not the fracture edge ), because thickness is usually greater at these points.

**5.9.4.3** Record the three thicknesses for each specimen. If results are consistently different for the two side measurements, this may indicate that the specimens do not have parallel faces, and the alignment of the press platens should be checked.

### **5.9.5 Specimen Width**

**5.9.5.1** Specimen width is assumed constant for the purpose of this test; however, optional determination of specimen width may be made at this point to allow the determination of true modulus of rupture, if desired.

**5.9.5.2** Use calipers with long thin parallel jaws which are perpendicular to the direction of extension. These will permit measurement of specimen width even with diagonal fractures.

**5.9.5.3** Record the width to the nearest 0.2 mm for each cake.

### **5.9.6 Dry Specimen Mass**

**5.9.6.1** After testing and measuring, return the broken specimens to the wire basket and place them in the drying oven. Alternatively, stack manually.

**5.9.6.2** Dry the specimens at 105-110°C for 24 h, excluding the time required to reach the specified temperature. Allow cakes to cool for minimum 30 min, but not longer than 2 h. Weigh cakes as soon as they can be handled with bare hands.

**5.9.6.3** Weigh both halves of each broken specimen together to the nearest 0.000 1 kg and record this mass for each specimen.

## **6. CALCULATION**

### **6.1 Standard Calculation**

**6.1.1 Specimen Volume** — Determine the volume of each specimen from the following equation:

$$V = (S - I)/D$$

where

$V$  = volume of specimen in m<sup>3</sup>,

$I$  = immersed mass in kg,

$S$  = saturated mass in kg, and

$D$  = density of water equal to 1 000 kg/m<sup>3</sup>.

**6.1.2 Dry Specimen Density** — Determine the dry density of each specimen from the following equation:

$$A = B/V = BD/(S-I)$$

where

$A$  = dry specimen density in kg/m<sup>3</sup>,

$B$  = dry specimen mass in kg, and

$V$  = volume of specimen in m<sup>3</sup>.

**6.1.2.1** In keeping with the limits on thickness imposed, the density may not exceed  $1.6 + 0.07 \text{ mg/m}^3$  to permit valid density corrections.

### 6.1.3 Flexural Strength

**6.1.3.1** Determine the flexural modulus of rupture from the following equation for a simple beam with centre point loading for each specimen:

$$MR = \frac{3 Pl}{2 bt^2}$$

where

$MR$  = modulus of rupture in N/m<sup>2</sup>,

$P$  = maximum load attained in N,

$l$  = span in m,

$b$  = width in m, and

$t$  = average thickness in m.

NOTE — If the true width has been measured, true flexural modulus of rupture may be calculated by substituting the true width for  $b$  in the equation.

**6.1.3.2** Determine the test modulus of rupture from the following equation:

$$MR_T = \frac{3 \times P \times 0.152}{2 \times 0.0762 \times t^2} = \frac{3P}{t^2}$$

where

$MR_T$  = test modulus of rupture in N/mm<sup>2</sup>,

$P$  = maximum load attained in N,

$t$  = average thickness in m,

0.152 = nominal span in m, and

0.0762 = nominal width in m.

**6.1.3.3** Correct the test modulus of rupture  $MR_T$  to a common density basis as follows, based upon the arbitrary choice of a standard density of  $1.6 \text{ mg/m}^3$ :

$$MR_A = \frac{(1.6 \times 10^6)^2 (MR_T)}{A^2}$$

where

$MR_A$  = adjusted modulus of rupture in  $\text{N/mm}^2$ ,

$A$  = dry specimen density in  $\text{kg/m}^3$ , and

$1.6 \times 10^6$  = standard density in  $\text{kg/m}^3$ .

**6.1.3.4** Eliminate any individual value of  $MR_A$  varying from the average by more than 7.5 percent of the average (including results on ten specimens) and calculate the new average strength. If more than three such specimens are to be eliminated, repeat the whole test.

**6.1.4 Reference Strength Level** — A standard reference strength for the asbestos cement specimens shall be taken as  $26.97 \text{ N/mm}^2$  at a dry cake density of  $1.6 \times 10^3 \text{ kg/m}^3$ .

#### 6.1.5 Calculation of Fibre Content to Give Standard Strength

**6.1.5.1** The asbestos fibre content of the dry mix should be so chosen that the adjusted modulus of rupture ( $MR_A$ ) lies in the range  $25.6$ – $28.2 \text{ N/mm}^2$ . If  $MR_A$  exceeds this range, prepare a new series of test specimens at a different fibre content as determined in **6.1.5.2**.

**6.1.5.2** Calculate the asbestos fibre mass required from the following equation:

$$F_A = \frac{(0.145 - F_A) (F_T) (275 \times 10^5)}{(0.145 - F_T) (MR_A)}$$

where

$F_A$  = adjusted fibre mass in the dry mix per specimen to give standard strength in kg,

$F_T$  = mass of asbestos fibre per specimen in kg,

$0.145$  = total mass of dry mix per specimen in kg, and

$275 \times 10^5$  = standard reference strength in  $\text{N/m}^2$ .

**6.1.5.3** The percent asbestos fibre required in the dry mix to give standard strength:

$$\begin{aligned} &= F_A \times 100/0.145 \\ &= \frac{275 \times 10^5 \times F_T \times 100}{MR_A (0.145 - F_T) + 275 \times 10^5 \times F_T} \end{aligned}$$

$$= \frac{275 \times 10^5 \times Q_f \times 100}{MR_A (1.00 - Q_f) + 275 \times 10^5 \times Q_f}$$

where

$Q_f$  = ratio of asbestos fibre mass to total dry mix mass.

### 6.1.6 Calculation of Strength Units

**6.1.6.1** An asbestos fibre that gives the standard strength at the standard density when used as 10 percent of the furnish is defined as having 100 strength units. Therefore, by knowing the percent asbestos fibre required in the mix to give standard strength, it is possible to calculate the strength units of the fibre sample from the following equation:

$$\text{Strength Units} = \frac{1\ 000}{\text{percentage required in dry mix}}$$

NOTE — A typical example for the calculation of strength units is given in Appendix A.

## 6.2 Point Value

**6.2.1** Point value is considered as an index of commercial value. One of the several available formulae is given below:

$$P. V. = (S. U. - 10) / 1.39$$

where

$P. V.$  = point value in points, and

$S. U.$  = strength unit, in units.

## 7. REPORT

**7.1** Fully identify the sample tested as to designation and origin.

**7.2** Report the following data:

- $Q_f$  ( ratio of asbestos fibre mass to total dry mix mass ) tested,
- $Q_f$  required,
- $MR_A$  average,
- Number of specimens acceptable,
- Strength units, and
- Point value, if calculated.

## 8. PRECAUTIONS

**8.1** Avoid overloading the humidity cabinet, water bath, and the drying oven beyond the point where rapid humidity and temperature equilibrium can be obtained.

**8.2** Ensure that the mould and platens are not worn beyond specifications.

**APPENDIX A**

( Clause 6.1.6.1 )

**A TYPICAL EXAMPLE FOR CALCULATION OF  
STRENGTH UNITS****A-1. DATA****A-1.1 Mix Composition**

$$Q_f = 0.125$$

$F_T$  = fibre mass in kg per specimen

$$= 0.145 \times 0.125 = 0.0181 \text{ kg.}$$

$C_T$  = cement mass in kg per specimen

$$= 0.6 \times (0.145 - 0.0181) = 0.0761 \text{ kg}$$

$S_T$  = silica mass in kg per specimen

$$= 0.4 \times (0.145 - 0.0181) = 0.0508 \text{ kg}$$

$$\begin{aligned} \text{Total mass for specimen} &= 0.0181 + 0.0761 + 0.0508 \\ &= 0.145 \text{ kg} \end{aligned}$$

**A-1.2 Strength Data**

$P$  = breaking load = 310 N

$T$  = average thickness at break

$$= 1/3 (5.90 + 5.90 + 6.20)$$

$$= 6 \times 10^{-3} \text{ m}$$

$A$  = dry specimen density = 1580 kg/m<sup>3</sup>

**A-2. CALCULATION****A-2.1 Flexural Moduli of Rupture**

$$MR_T = \frac{3P}{l^2} = \frac{3 \times 310}{(6 \times 10^{-3})^2} = 258 \times 10^5 \text{ N/m}^2$$

$$\begin{aligned} MR_A &= \frac{(1600)^2 (258 \times 10^5)}{(1580)^2} \\ &= 265 \times 10^5 \text{ N/m}^2 \end{aligned}$$

### A-2.2 Percent Fibre Required

$$\begin{aligned}
 &= \frac{275 \times 10^5 \times F_T \times 100}{MR_A (0.145 - F_T) + 275 \times 10^5 F_T} \\
 &= \frac{(275 \times 10^5) (0.0181) (100)}{(265 \times 10^5) (0.145 - 0.0181) + (275 \times 10^5) (0.0181)} \\
 &= 12.9 \text{ percent or} \\
 &= \frac{275 \times 10^5 \times Q_f \times 100}{MR_A (1.00 - Q_f) + (275 \times 10^5) Q_f} \\
 &= \frac{275 \times 10^5 \times 0.125 \times 100}{265 \times 10^5 (1.00 - 0.125) + 275 \times 10^5 (0.125)} \\
 &= 12.9 \text{ percent}
 \end{aligned}$$

### A-2.3 Strength Units

$$\begin{aligned}
 \text{Strength Units} &= 1\,000 / (\text{percent fibre required}) \\
 &= 1\,000 / 12.9 = 78 \text{ units}
 \end{aligned}$$

( Continued from page 2 )

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